Reappraisal of the fossil seal *Phoca vitulinoides* from the Neogene of the North Sea Basin, with bearing on the geological age, phylogenetic affinities, and locomotion of a diminutive Miocene phocine species.

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Abstract

Among secondary aquatic tetrapods, pinnipeds are among the few taxa to retain the capacity to move on land. Hence, pinnipeds can be regarded as a group which' transition from land to sea is still in progress.

Ever since the initial establishment of the fossil species *Phoca vitulinoides* by Van Beneden in 1871 and its more detailed description in 1877, this phocid (Pinnipedia, Phocidae) remained largely unstudied until now. More recently, the validity of *P. vitulinoides* as a species was questioned, despite the fact that the number of specimens assigned to this taxon substantially exceeds all other Neogene fossil seal taxa from the southern North Sea Basin. Hence, a reinvestigation is needed.

Spurred by the recent acquisition of several partial postcranial skeletons by the Royal Belgian Institute of Natural Sciences, the current study clarifies multiple aspects of our knowledge of *P. vitulinoides*.

First, the stratigraphic interval occupied by the species is redefined. While originally assigned to the –currently disused– early Pliocene 'Scaldisian' stage, the species is now identified in upper Miocene layers. At least part of the previously recognized Pliocene records may in fact be isolated bones reworked in the gravel at the base of the Zanclean Kattendijk Formation.

Second, an exhaustive cladistic analysis of *P. vitulinoides* nests the species among species of *Pusa* (including the ringed, Caspian, and Baikal seals). While the exact position relative to *Pusa* spp. remains poorly resolved, it is clear that *P. vitulinoides* is more closely related to *Pusa* than to *Phoca.* While only tentatively proposed in the past, this assignment is robustly supported in the current analysis. The smaller size, shallow gluteal fossa of the innominate, and highly raised greater trochanter of the femur are the most prominent characters distinguishing *P. vitulinoides* and extant species of *Pusa* from *Phoca.*

Finally, the renewed anatomical description reveals important osteological characters correlated with limb musculature and aquatic locomotion. A large humeral head, weakly developed lesser tubercle compared to the greater tubercle, and deep insertion scars for the supraspinatus and

infraspinatus muscles on the humerus suggest an increased mobility and a more intensive, and less derived, use of the forelimb for propulsion as compared to most other phocines. Similarly, a greatly enlarged greater trochanter of the femur, a strongly concave patellar facet on the femur, and a strongly developed popliteal surface on the tibia suggest an intensive use of the hind limb during swimming.

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